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Dear Sir:

Information Disclosure Statement of A Machine for Production of Granular Silicon

By Stephen Michael Lord

Pursuant to the guidelines for Information Disclosure Statements set forth in 37 C.F.R. Sections 1.97-1.99 and MPEP Section 609, Applicant(s) submit(s) herewith patents, publications or other information of which he/she/they is/are aware, which is believed to may be material to the examination of this application and in respect of which there may be a duty of disclosure in accordance with 37 CFR 1.56.

A list of patent(s) and/or publication(s) is set forth on the attached Form "Information Disclosure Statement by Applicant." A copy of each item listed is supplied herewith.

US Patent # 5,037,503 ; Aug 6, 1991; Kajimoto et al.

Method for growing silicon single crystal using silicon granules discloses hydrogen content of 7.5 ppmwt and chlorine content of 15 ppmwt or less is required to avoid a bursting phenomenon which would disturb the growth of the crystal Meeting the above requirements in a single reactor requires high reactor inlet temperatures such as can be provided by this method. Since single crystal growth is the primary market for silicon, being able to meet this purity requirement without additional processing is an important benefit of the invention.

US Patent # 3,012,861; Dec 12 1961; Ling.

Successful production of high purity silicon using an all quartz system. Demonstrates the acceptance of the need to use quartz reactors to obtain high purity material

US Patent 4,416,913; Nov 22,1983; Ingle et al.

Use of a quartz reactor and microwave heating are beneficial. Bead circulation and segregation can be induced using an annular design with beads lifted up the center and going down the outside Illustrates the established use of quartz and that microwaves pass through quartz and heat silicon. Is an example of the complexity of prior technology, the difficulty of obtaining the needed heating and the need to cool the interior partitions. The avoidance of these problems is a benefit of this invention

Journal of Crystal Growth, vol 64. 1983, A. M. Beers et al "CVD Silicon Structures Formed by Amorphous and Crystalline Growth" pp. 563-571.

The deposition of silicon proceeds in two steps, the deposition of hydrogen containing amorphous silicon followed by the crystallization of the silicon and the release of hydrogen. The crystallization process requires higher temperatures than the decomposition process and the time

required is dependent on the temperature and on the deposition rate. For nearly instantaneous crystallization the temperature must be in excess of 800 C at commercially desired deposition rates of 2-3 micron/min. This reference describes the mechanism of the crystallization and the minimum conditions needed to obtain in-situ crystallization and hence dehydrogenation during deposition. The high temperatures required to do this must be provided at the inlet where the deposition rate is highest and the product beads are removed. The invention has the major benefit of being able to achieve these temperatures and thus can obtain the purity required for single crystal growth in a single reactor which is a major advantage compared to the competing technology of Allen which requires a separate dehydrogenation step.

US Patent 4,784,840; Nov 15, 1988; Gautreaux & Allen.
Discloses a severe problem with dusting in a silane based fluidized bed and use of a two step process to overcome it. Also discloses the low operating temperature of 620-650 C and the very thin deposit 0.1-0.5 micron deposited in the second mode. Based on the deposition time of 30 minutes the deposition rate can be calculated at 0.0.003- .016 micron/min Avoiding dusting by use of higher temperatures is a major benefit of this invention and depositing at a rate of 2-3 micron/min is much preferable to a rate 500 times lower.

US Patent 5,242,671;Nov. 13, 1991;Allen et al.
The hydrogen content of silicon beads can be reduced by heating to a temperature between 1020-1200 C in a fluidized bed for 1-2 hours dependent on temperature Avoidance of this additional step is a major advantage of this invention and is due to the higher temperatures during deposition that the invention provides.

U.S. Patent 4,092,446 May 30,1978 by Padovani et al
Discloses a complete process for refining impure silicon to produce purified electronic grade silicon. This process is very similar to the processes used by most electronic grade silicon and provides detailed information and a typical flow diagram and mass balance for a balanced system where there is little waste material. The background reference provides a good description of the current state of the art and the mass balance and process flow diagrams in it are used to show the need to recirculate silicon tetrachloride and the benefits of the feedstock recovery system of the present invention.

U.S. Patent 5,798,137 Aug 25 1998 by Lord et al
Discloses the need to heat a reactor to greater than 800 C in the inlet zone to avoid hydrogen contamination, according to the article by A. M. Beers, the difficulties of heating a fluid bed reactor to this temperature and the benefits of providing jet heating via laser or chlorine combustion of the silane feedstock for this purpose. Uses a single uncooled gas inlet to avoid the heat losses associated with a cooled distributor. Shows how difficult the problem of heating the beads to the required temperature is when close to the silane inlet. It also discloses adding the system appropriate halogen or hydrohalide to the effluent of the reactor to reduce dust and improve safety and operation. It provides a detailed discussion of the issues relating to silicon deposition and fluidized beds in particular, provides a list of terminology and an exhaustive list of prior patents in this area. The reference illustrates the need to heat the fluid bed to a high temperature and the difficulty of doing so and thus illustrates the benefits of the present invention which minimizes or eliminates the requirement for such heating.

US Patent 5,810,934 Sep 22, 1998; Lord et al.

Provides a silicon deposition apparatus with multiple zones and provides for heat recovery from the outlet product by heating the incoming silicon containing gases. Discloses use of a thermal isolation tube between the wall of the bead tube and the wall of the silicon source gas tube to prevent wall deposits. Illustrates the difficulty the prior technology had in recovering heat from the product because of the wall deposits which would form. Recovering the heat from the product by heating the non decomposable gas avoids wall deposit problems and is a benefit of this invention.

US Patent 5,374,413; Dec. 20, 1994: Kim et al .

Notes that cooling of the wall as suggested by Poong is not effective in preventing wall deposits and greatly increases power consumption of the microwave heating system and suggests a partition between the heating and reacting zones similar to Ingle and Van Slooten. Provides separate distribution means for the heating zone and reacting zone similar to Van Slooten. Discloses gas distribution means for the silicon source gas was cooled to below 400 C. Illustrates more of the difficulties of heating a fluid bed decomposition reactor through the wall even when using microwaves and of the problems of the prior technology in achieving the required temperatures particularly near the inlet of the silicon source gases . This reinforces the benefits of the present invention which minimizes or eliminates the requirement for such heating.

US Patent 4,207,360; Jun. 10 1980; Padovani.

Provides for two zones of different temperatures to encourage particle breakage. Discloses that optimum temperature for trichlorosilane base reactors is 1100 C as this increases the yield of silicon by promoting the hydrogen reduction reaction. Discloses use of graphite bricks in the construction of the reactor. It identifies the desired temperature of 1100 C for trichlorosilane based systems and the cause, use of graphite bricks, which led to contamination of the product with carbon and failure of the method to be accepted. The capability of this invention to reach 1100 C without use of graphite or other carbon containing materials is a major benefit.

US Patent 4,992,245; Feb. 12, 1991; Van Slooten et al.

Provides a heating zone annulus where the particles enter at the top, are heated then leave at the bottom, discloses use of a pulsed gas jet to move particles from the outer annulus into the inner annulus and provides separate gas distribution means for hydrogen used to fluidize the beads in the outer annulus and a silane containing gas used to fluidize the beads in the inner annulus. Discloses high heat losses at the cooled distributor. Illustrates the need for improved heating and the difficulty the prior technology has in providing the needed heat close to the grid.

US Patent 4,818,495; Apr. 4, 1989; Iya.

Provides an upper heating zone where the beads are heated then mixed with the particles in a lower zone which contact a silane containing gas which has passed through a lower cooled gas distribution zone. Shows that cooling the grid and providing the heat in the upper zone sets up a temperature profile where the reactor above the grid is too cold. (500 C) to obtain the hydrogen purity requirements in a single step. Avoiding this problem of the prior technology is a major benefit of this invention.

US Patent 4,424,199;Jan 3, 1984; Iya.

Describes a fluid jet seed particle generator inserted in a "hydrogen boot" located below the reactor which was intended to separate the new small seed particles from the product. Illustrates the difficulty of separating the new seeds from the larger product. Avoiding this problem is a major benefit of the sieving technology proposed in this invention.

US Patent 4,900,411; Feb. 13, 1990; Poong & Yongmak.

Describes a method and apparatus for producing silicon in a fluidized bed reactor using microwaves to heat the reactor. Discloses need to cool gas distributor and wall to prevent silicon deposits which can prevent the passage of microwaves into the reactor. Describes some of the problems of using microwaves to heat the reactor which illustrates that not requiring microwave heating is a benefit of this invention

While this Information Disclosure Statement may be "material" pursuant to 37 CFR 1.56, it is not intended to constitute an admission that any patent, publication or other information referred to therein is "prior art" for this invention unless specifically designated as such.

Respectfully submitted,

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Sheet 1 of 2

Complete If Known	
Application Number	
Filing Date	
First Named Inventor	STEPHEN MICHAEL LORD
Group Art Unit	
Examiner Name	
Attorney Docket Number	

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U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	U.S. Patent Document Number	Kind Code[2] (if known)	Name of Patentee or Applicant of Cited Document	Date of Publication of Cited Document MM-DD-YYYY	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	5037503		Kajimoto	08/06/91	
	2	3012861		Ling	12/12/61	
	3	4416913		Ingle	11/2283	
	5	4784840		Gautreaux & Allen	11/15/88	
	6	5242671		Allen	11/13/91	
	7	4092446		Padovani	05/30/78	
	8	5798137		Lord	08/25/98	
	9	5810934		Lord	09/22/98	
	10	5374413		Kim	12/20/94	
	11	4207360		Padovani	06/10/80	
	12	4992245		Van Slooten	02/12/91	
	13	4818495		Iya	04/04/89	
	14	4424199		Iya	01/03/84	
	15	4900411		Poong & Yongmak	02/13/90	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Office[3]	Number[4]	Kind Code[5] (if known)	Name of Patentee or Applicant of Cited Document	Date of Publication of Cited Document MM-DD-YYYY	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

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Sheet	2	of	2

Complete If Known	
Application Number	
Filing Date	
First Named Inventor	STEPHEN MICHAEL LORD
Group Art Unit	
Examiner Name	
Attorney Docket Number	

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OTHER PRIOR ART – NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	4	BEERS, A. M. CVD Silicon Structures Formed by Amorphous and Crystalline Growth.Journal of Crystal Growth vol64 1983, pp 563 571	

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